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# WESTAR: AMERICA'S FIRST FULLY COMMERCIAL RECOVERABLE SPACE SERVICE

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Thomas Wonder
*Westinghouse Electric Corporation, Huntsville, Alabama*
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***ABSTRACT***

*The WESTAR service -- Westinghouse Space Transportation and Recovery -- is a fully integrated, commercially operated service to fly payloads into low-Earth orbit for extended duration missions, and return payloads safely to Earth in a Recovery System. After recovery, other payloads on the same mission can continue operating in a Service Module bus providing satellite services. The system to provide this service is currently being built for the first of three orbital missions for the COMmercial Experiment Transporter (COMET) Program. The first flight using this system will be launched from Wallops Flight Facility, Virginia during the first quarter of 1993, with recovery 30 days later at the Utah Test and Training Range.*

## INTRODUCTION

For those who require low-cost, fast-turnaround access to space, Westinghouse is providing WESTAR (Westinghouse Space Transportation and Recovery), a fully integrated service which offers a "ticket to space" for users, either one-way or round trip. While in orbit, the WESTAR service provides basic utilities as required, such as electric power, cooling, pressurized air, data management, and communications.

WESTAR is designed to launch on a small expendable launch vehicle, so flights can be scheduled with reliable frequency to accommodate a wide range of research and production programs. The WESTAR service provides flexible payload accommodations by means of a two-part spacecraft, consisting of a Recovery System and a Service Module. Access to payloads is possible up to 6 hours before launch for installation of degradable materials, and for the Recovery System, payloads can be accessed on the ground within 4 hours of separation from the Service Module.

This paper provides a brief background on WESTAR and its forerunner program, COMET (COMmercial Experiment Transporter). Technical details of launch/orbital parameters and payload accommodations for a nominal WESTAR mission are provided.

## BACKGROUND

Until now, the commercial development of space in the United States -- especially requiring recoverable payloads -- has been mainly tied to Space Shuttle flights. The number of experimenters who have used the Shuttle, compared to those who would like to place experiments in space, is relatively small for various reasons, including high cost, lack of man-rating, or less-than-the-highest priority. Also, there are numerous arguments why the Shuttle is not an ideal vehicle for many experimenters: (1) man-rating an experimenter's payload imposes delay and additional cost on the experimenter, (2) the microgravity environment is not good enough, and (3) the time in space is too short.

At a meeting of Directors for the NASA-sponsored CCDSs (Centers for Commercial Development of Space) in Houston, in early 1990, Mr. James R. Rose, NASA Office of Commercial Programs (Code C) put forward a challenge: *establish a program to encourage the development of a commercial space industry that is not linked to the Shuttle or that requires extensive government involvement.* Included in the rationale:

- The CCDSs and their industrial partners require long duration flights - longer than the Shuttle will allow.

- Shuttle flight opportunities are becoming increasingly more limited.

- Studies revealed an existing market for commercial space.

The COMET (COMmercial Experiment Transporter) Program came into being as a result of that challenge. The Program Plan was approved by NASA Code C in May 1990 with Mr. Joseph Pawlick, Program Manager, of the Center for Space Transportation and Applied Research in Tullahoma taking the lead. The primary aim of the COMET Program is to buy access to space and related services -- but not the associated hardware and systems -- from qualified contractors. Highlights of the Program Plan:

- Statements of Work are written for performance, not for hardware.

- Recoverability (required in 75% of payloads) is built into the system.

- Design is the responsibility of the contractor team.

- No Mil Standards or NASA Standards need to be followed.

- Quality is responsibility of the contractor team.

- Hardware and systems are property of the contractors.

A draft RFP was released in July, 1990, with the final RFP issued August 22, 1990 covering six contract areas. Contractor selection was completed March 8, 1991: The work areas, their respective CCDS monitors, and contractors selected (*italicized*) are shown:

**Systems Engineering**: Center for Space Transportation and Applied Research, University of Tennessee Space Institute / Calspan Operations; *Westinghouse Electric Corporation.*

**Payload Integration**: Center for Macromolecular Crystallography, University of Alabama at Birmingham; *Space Industries Inc.*

**Launch Vehicle**: Consortium for Materials Development in Space, University of Alabama in Huntsville; *EER Systems.*

**Service Module**: Center for Space Power, Texas A&M University, College Station; *Westinghouse Electric Corporation.*

**Recovery System**: Bioserve Space Technologies, University of Colorado, Boulder; *Space Industries, Inc.*

**Orbital Operations**: Space Vacuum Epitaxy Center, University of Houston; *Space Industries, Inc.*

The authority to proceed was given on April 8, 1991, and initial payloads' selection was completed June 24, 1991. The contracts call for three missions during 1993, 1994, and 1995, with two optional missions in 1996 and 1997. All Preliminary Design Reviews (PDRs) were accomplished by September 1991, with all Critical Design Reviews (CDRs) completed by November 1991.

## STATUS

Most of the flight hardware for the first COMET flight has been built and tested, including high altitude drop tests of the Recovery System. A Commercial Payload Operation and Control Center (COMPOCC) has been completed in Houston and is operational, currently tracking satellites for calibration purposes. Experiment payload integration and test will commence in October, 1992 at Houston. The first mission will be launched during the first quarter of 1993 from Wallops Island, Virginia, with recovery 30 days later at the Utah Test and Training Range west of Salt Lake City.

Parallel to the COMET Program, which is only available to the CCDSs and their associates, Westinghouse established the privately financed WESTAR service, which is available to any user with a need to access space. A similar spacecraft design, and the same facilities for launch, payload

integration, orbital operations, and recovery are available from Westinghouse as a single point of contact. The first WESTAR mission is scheduled for the first quarter of 1994, with a potential of 10 missions per year by 2000. Negotiations are currently underway with potential users.

Descriptions of the mission and payload accommodations which follow are for the WESTAR service.

## MISSION DESCRIPTION

WESTAR is a fully integrated space transportation and recovery service that can carry payloads to the environment of space, leave some there, and return with others. Basic utilities such as electric power, controlled temperature and pressure, spacecraft orientation, data management and communications are provided while in orbit.

Each mission is capable of launching a two-part spacecraft - carrying payloads into a 300 nautical mile circular orbit - consisting of a Recovery System which returns to land after 30+ days by parachute, and a non-recoverable Service Module which stays in orbit for 2+ years (Figure 1). Payloads run the gamut from material studies to communications to life sciences.

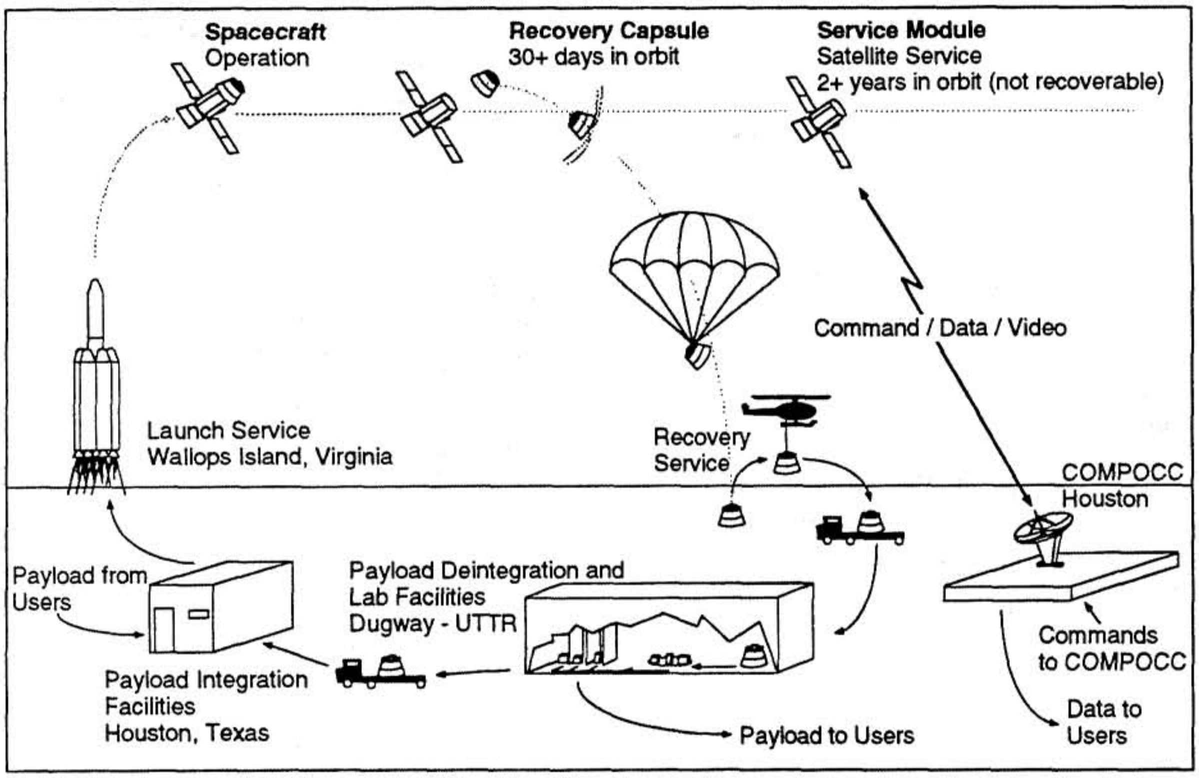


**Figure 1 - WESTAR Service Concept**

The WESTAR service concept consists of the following major elements:

**Payload Integration** - Payloads are integrated into the Recovery Capsule and the Service Module through an extended period of interface with the user. This interface includes the exchange of appropriate interface documentation, face-to-face meetings to work out integration issues, required preflight testing and mockups, and subsequent delivery of the payload(s) for final integration into the Recovery System and Service Module. The Recovery System and Service Module are then integrated into a single spacecraft, and preflight testing of the spacecraft is completed. Late access to payloads is provided up to approximately 6 hours before launch.

**Launch** - The spacecraft is mated to the launch vehicle, the fairing is secured over the

spacecraft, final testing is completed, and all other preparations for launch are completed. The launch vehicle with spacecraft aboard is then launched and monitored to orbital insertion. A CAD representation of the WESTAR spacecraft is shown in Figure 2.

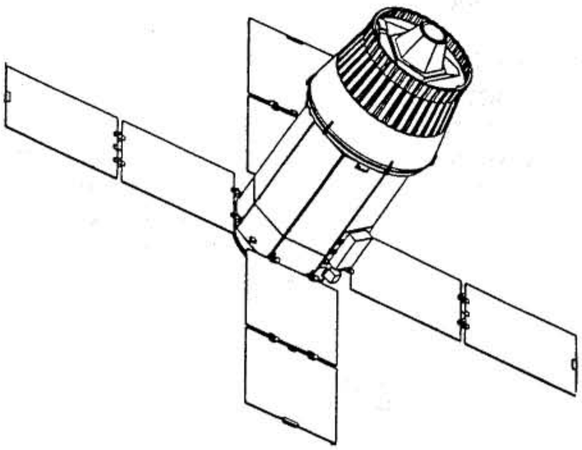

**Figure 2 - WESTAR Spacecraft**

**On-orbit Operation** - After the spacecraft is placed in orbit, solar arrays on the Service Module are deployed and initial operational testing of the spacecraft is completed. Operation of payloads then begins, and continues for a few days up to several years, depending on the requirements of the payload.

**Acquisition of Payload Data While On-orbit** - During on-orbit operation, data downlinked from payloads is received at the COMPOCC and provided to the user either at the COMPOCC or via a communication link to a remote location.

**Recovery Operation** - When orbital operation of a recoverable payload is completed after 30+ days after launch, the Recovery System is spin-stabilized, pointed for the re-entry maneuver, and separated from the Service Module. A deorbit motor aboard the Recovery System is fired and the capsule re-enters the atmosphere. A parachute system slows the capsule for landing, and a shock attenuation system absorbs the final impact with the ground.

**Payload Deintegration and Return to User** - The Recovery System is immediately transported to nearby facilities where the payload is removed. An early access capability of 4 hours is achievable. Users may work on their payloads in the recovery site facilities, or the payloads can be shipped to the user's choice of destination.

**Continued Operation of the Service Module** - Payloads in the Service Module can continue operating long after the Recovery System has separated and re-entered. Payloads not requiring recovery, for example, astronomical observation, earth observation, atmospheric monitoring, navigation, search and rescue, and communications operations can all be accomplished aboard the Service Module during this time.

WESTAR missions can be accommodated on either a dedicated or shared basis. With a dedicated mission, the user has full control over scheduling of the launch date, selection of orbital parameters, and scheduling of system resources such as electric power. Dedicated missions also offer a significant reduction in cost per pound of payload. On shared missions, scheduling of launch date and use of resources are allocated to accommodate all users.

Standard WESTAR missions are scheduled for launch from the Wallops Flight Facility (WFF) in Virginia, and recovered at the Utah Test and Training Range (UTTR) near Bonneville, Utah. Both locations are at approximately 40° inclination from the equator, offering the maximum number of passes over the recovery area for a given mission. Both have ground facilities to conduct required payload integration and de-integration activities, and can provide laboratory and other support to the user.

Alternate launch, landing, and orbital operations sites can be accommodated based on the user's requirements.

## PAYLOAD ACCOMMODATIONS AND SUPPORT SYSTEMS

The two-part WESTAR spacecraft design is modular, providing maximum flexibility for payload accommodations.

This modularity and reconfigurability allows users to send a wide range of materials, equipment, and systems into space. Figure 3 provides a graphic representation of the payload accommodation spaces for both the Recovery System and Service Module, which offer payload volumes of 10 and 15 cubic feet respectively, and a total of 550 lbs allocated between the two carriers. Payload volume in the Recovery System can be increased to 12 cubic feet, allowing an additional 50 lbs for a total of 600 lbs, if the pressurized container is eliminated and the payload is exposed to the vacuum of space.

**Thermal Control** - The Service Module and Recovery System are independently cooled, each using a capillary pump loop (CPL) two-phase ammonia system. The CPL system is capable of maintaining the payloads at 72 ± 5° F with a heat input of up to 400 watts. The advantage of the CPL system is the lack of mechanical pumps, valves, and relays which can create microgravity disturbances to the payload environment.

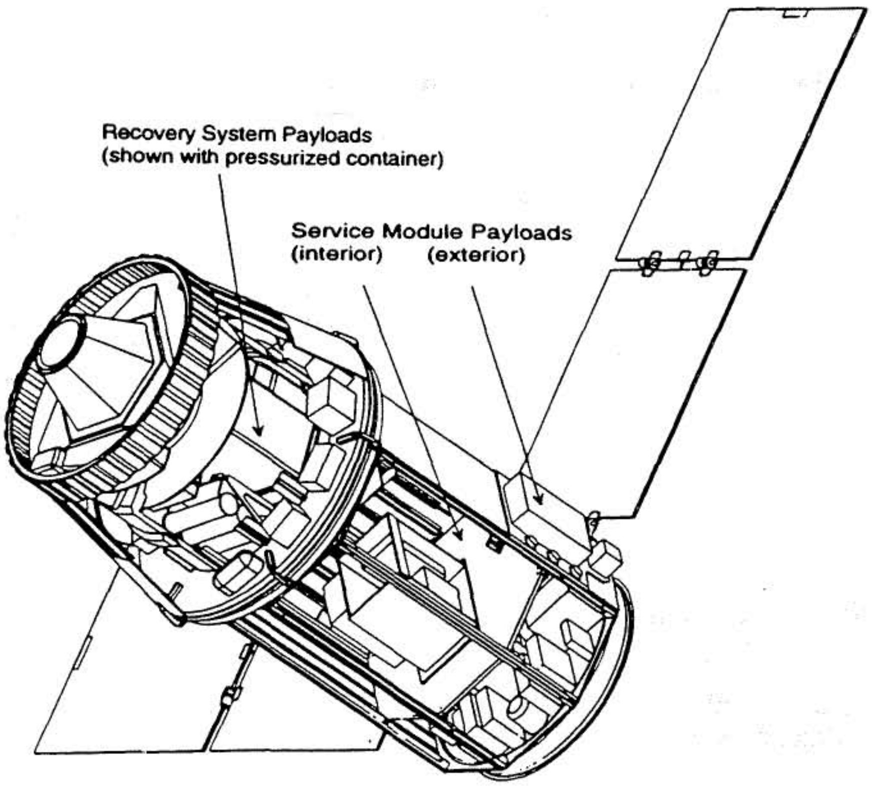


**Figure 3 - Payload Accommodation Spaces**

**Attitude Control** - The attitude control system (ACS) onboard the Service Module is a 3-axis system with 4 major operational modes: (1) alignment for orbit insertion, (2) solar-pointing, (3) earth-pointing, and (4) reentry pointing for the Recovery System. A microgravity environment of 10 to the minus 5 g is maintained during the solar and earth-pointing modes using a combination of reaction wheels and 3-axis torque coils. Solar-pointing of ± 0.5° is assisted by a fine sun sensor, and earth-pointing of ± 1° is controlled by a reaction wheel in a momentum bias mode. Orientation during both solar and earth-pointing is supplied by a horizon scanner. Cold gas thrusters are used for the orbit insertion maneuver, reentry alignment, and for off-setting the spin table torque during the Recovery System spin balance prior to reentry release. Orbit insertion and reentry alignment are controlled by a 3-axis inertial measurement unit.

**Power** - The Service Module power system provides 28 ± 4 volts DC for all payloads and housekeeping. Four solar panels, in combination with rechargeable

batteries, generate sufficient power to allocate 350 watts continuous and 400 watts for up to 200 hours to the payloads.

**Payload Data** - The spacecraft has provisions for a total of twelve ports, each providing a data, power and video interface. In addition, each port can be multiplexed to ten locations, thus accommodating up to 120 payload components. A command and data handling processor has an allocated memory of 1 Mb for Service Module telemetry and 3 Mb for payloads. Data interface is RS422 with X-modem protocol. Also available is a standard NTSC video format. The RF data downlink is 250 kbps and uplink command is 9.6 kbps. At the downlink data rate, the 4 Mb memory can be downloaded in just over 2 minutes of 50 minutes per day available for two-way communications. During the mission, command uplink and payload downlink telemetry is managed through the COMPOCC in Houston. The COMPOCC also supports remote user's requirements via modem data transfer.

A summary of WESTAR integrated payload capabilities is presented in Table 1.

**Table 1 - WESTAR Integrated Payload Capabilities**

| | | Recovery System | Service Module |
|---|---|---|---|
| **Payload Mass** | | up to 600 / 550 lbs* | up to 550 lbs* |
| **Payload Volume** | | 12 / 10 $ft^3$ | 15 $ft^3$ |
| **Environment** | • Microgravity | $1 \times 10^{-5}$ g | |
| | • Pressure | vacuum / 1 atm | vacuum |
| | • Baseplate Temp. | $72 \pm 5°$ F | $72 \pm 5°$ F |
| **Power** | • Voltage | $28 \pm 4$ VDC | |
| | • Continuous | 350 watts | |
| | • Peak (200 hours) | 400 watts | |
| | • Transient | 1000 watts | |
| **Heat Rejection** | | 400 watts | 400 watts |
| **Communication** | • Downlink (& Video) | 250 Kbps | |
| | • Uplink | 9.6 Kbps | |
| | • Time | Five 10-minute periods per day | |

*Combined payload mass in the Service Module and Recovery System.

## SUMMARY

Westinghouse Electric Corporation has developed a new way for users to access space through a commercial initiative, the WESTAR service, a derivative of the CCDS COMET Program. With WESTAR, users can reliably fly recoverable payloads and non-recoverable payloads - up to a total of 600 lbs - on the same mission by means of a separable Recovery System mated to a Service Module, a three-axis stabilized spacecraft bus powered by solar arrays and rechargeable batteries. A nominal mission is launched to a 300 nautical mile circular orbit at an inclination of 40°. A nominal mission length is 30 days in orbit for the Recovery System and up to 2+ years for the Service Module.

The first flight using this system will be launched from Wallops Island, Virginia during the first quarter of 1993, with recovery 30 days later at the Utah Test and Training Range.